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Research paper

Correlations of decision weights and cognitive function for the masked discrimination of vowels by young and old adults

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ABSTRACT

Older adults are often reported in the literature to have greater difficulty than younger adults understanding speech in noise [Helfer and Wilber (1988). J. Acoust. Soc. Am, 859–893]. The poorer performance of older adults has been attributed to a general deterioration of cognitive processing, deterioration of cochlear anatomy, and/or greater difficulty segregating speech from noise. The current work used perturbation analysis [Berg (1990). J. Acoust. Soc. Am., 149–158] to provide a more specific assessment of the effect of cognitive factors on speech perception in noise. Sixteen older (age 56–79 years) and seventeen younger (age 19–30 years) adults discriminated a target vowel masked by randomly selected masker vowels immediately preceding and following the target. Relative decision weights on target and maskers resulting from the analysis revealed large individual differences across participants despite similar performance scores in many cases. On the most difficult vowel discriminations, the older adult decision weights were significantly correlated with inhibitory control (Color Word Interference test) and pure-tone threshold averages (PTA). Young adult decision weights were not correlated with any measures of peripheral (PTA) or central function (inhibition or working memory).

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1. Introduction

With increasing age understanding speech in noise can become challenging, as evidenced by multiple studies comparing performance of younger and older adults in speech-in-noise recognition tasks (Bouma and Gootjes, 2011; Helfer and Wilber, 1988; Pichora-Fuller et al., 1995; Stewart and Wingfield, 2009; Tun and Wingfield, 1999). The often observed poorer performance of older adults in these studies has been attributed to a variety of factors, ranging from reduced hearing sensitivity (Humes et al., 1994; van Rooij and Plomp, 1990) to declining cognitive function with increasing age (Craik, 1965; Guerreiro et al., 2010; Inglis and Caird, 1963). Tun and Wingfield (1999), for example, asked younger and older adults to recall a target talker sentence presented simultaneously with different types of distracters (single talker, two talkers, babble, or white noise) at different levels of intensity. Unlike many of the younger adults, the older adults' word recall performance was negatively affected by the intensity and type of the distracter. The amount of variance in their data explained by measures of cognitive function and hearing sensitivity suggested that the difference in performance could be attributed both to a decrease in speed of processing with increasing age and to generally poorer hearing. Huang et al. (2010) used a priming paradigm to evaluate if familiarity with a target speaker's voice would reduce the amount of informational masking of the target speech in a background sound. The participants were asked to repeat a target sentence that was played simultaneously with two-talker babble (speech-in-speech condition) or steady speech-spectrum noise (speech-in-noise condition). The target sentences were syntactically correct, but were not semantically meaningful. On the priming trials, a sentence spoken by the target speaker was played in isolation prior to each target plus masker trial. The priming trials were compared to non-primed trials. Younger adults showed a significant release from masking when the primer was present in the speech-in-speech condition, but older adults did not show this effect, suggesting a failure to use an efficient decision strategy (however, also see Agus et al., 2009; Helfer and Freyman, 2008). Several other studies have used canonical correlation analysis, regression, and principal component analysis in an attempt to identify the relative

Abbreviations: F0, fundamental frequency; F1, first formant frequency; F2, second formant frequency; PTA, pure tone averages; SD, standard deviation; ADRC, Wisconsin Alzheimer's Disease Research Center; 2IFC, Two-interval, forced-choice

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importance of factors affecting differences in speech perception among young and older adults. The amount of variance with increasing age that can be explained by audiological test results (pure tone thresholds, speech recognition thresholds, etc.) varies in these studies from 48 to 75%. Cognitive measures by comparison (memory, speed of processing, IQ, etc) account for 24–33% of the variance (Humes et al., 1994; van Rooij and Plomp, 1990).

To date, research has focused on the relationship between different measures of cognitive function and tests of performance accuracy, such as percent correct and masked threshold. Most of the available research underscores group differences between young and old adults. However, there is a great deal of variation in the physical aging process of older adults and there is no known biomarker of age, making it difficult to group older adult's physical functions by chronological age (Dollemore, 2009). It is important to not only understand differences in hearing function between young and old adults, but also what factors might account for individual differences within these groups. The present study aimed to gain a better understanding of the individual differences in speech recognition performance among older listeners by measuring listener decision weights that reflect the relative reliance listeners place on target and masker (cf. Berg, 1990; Lutfi and Liu, 2011). Decision weights potentially offer greater insight into the reason for performance differences among individuals by providing an estimate of how listeners make use of information in the target and masker; that is, measuring *how* listeners perform the task in addition to *how well* they perform the task. This approach has not previously been taken to investigate the differences in masked discrimination of vowels among older adults, nor have decision weights been linked with cognitive measures in previous studies.

2. Materials and methods

2.1. Stimuli

The stimuli were sequences of synthesized steady vowels patterned after adult speakers of American English presented as masker-target-masker triads (Hawks and Miller, 1995; Klatt and Klatt, 1990; Nearey, 1989). This set of stimuli provided the experimental control necessary to calculate decision weights and in turn, to evaluate individual differences beyond percent correct. The decision weight calculation is explained in the calculation section. The synthesized vowels had frequencies below 3000 Hz which reduced the likelihood that presbycusis would confound any differences between young and old participants. Vowels were chosen over pure-tone complexes to allow for a slightly greater degree of generalization to "real world" speech-in-speech listening conditions. The masker-target-masker triads were modeled after the interleaved-word paradigm of Kidd et al. (2008) to minimize the amount of energetic masking, or failure of frequency analysis at the level of the cochlea, and focus on informational masking. For the purposes of this paper, informational masking is defined as masking that cannot be explained by known processes occurring at the auditory periphery, but rather is an effect of such factors as uncertainty regarding the acoustic properties of the masker, perceived similarity of target and masker, and attention and memory. Both informational and energetic masking contribute to the difficulty older adults report when listening for a target sound during noisy listening conditions. However, informational masking has been shown to have a profound detrimental influence on performance, specifically in speech-in-speech listening conditions (Brungart et al., 2006); therefore it was the focus of the current study. The interleaved-word paradigm greatly reduces the amount of energetic masking because the words no longer overlap simultaneously in frequency and time causing a breakdown at the level of the peripheral auditory system. Because the interleaved paradigm has been shown to elicit little or no energetic masking, the decrease in percent correct from listening to a single target sentence in isolation to listening for a target sentence interleaved temporally with a distracter sentence has been explained by informational masking.

All vowels had a duration of 250 ms and were separated from one another by 20 ms silent intervals. For such conditions, little forward or backward energetic masking is expected (Dorman et al., 1977). All vowels had a constant first-formant frequency (F1) = 250 Hz and a variable second-formant frequency (F2). F2 varied in 50-Hz increments from 1000 to 2000 Hz yielding 20 sounds. The perceived vowel varied from/i/as in "beet" (with a high F2) to/u/as in "boot" (with a low F2). In the first condition (F0-same), both the middle target vowel and the flanking masker vowels had a male fundamental frequency (F0) of 132 Hz. In the second condition (F0-different), the masker vowels had a female F0 of 220 Hz while the target vowel maintained the male F0 of 132 Hz. The F2 value was randomly selected with equal probability on each presentation from the range 1000–2000 Hz. The F2 of the target vowels were chosen independently from the F2 of the masker vowels. Within each triad the formant frequencies of the masker vowels were constrained to be the same. The vowels were presented diotically over Beyerdynamic DT 990 headphones to participants seated in a double-walled, Industrial Acoustics (IAC), sound-attenuated chamber. They were played at a 44,100 Hz sampling rate with 16 bit resolution using a MOTU 896 audio interface. The level of the vowels was calibrated so that the overall sound level at the eardrum was approximately 70 dB SPL (see Lutfi et al., 2008).

2.2. Procedure

Two randomly-selected, masker-target-masker triads made up each trial of a two-interval, forced-choice (2IFC) design. A silent period of 0.5 s separated the two intervals. Because the participants had no known background in acoustics it was impractical to ask them to discriminate F2. Therefore, in all conditions the participant was instructed to choose the interval containing the target vowel closest to an/i/. The participant response was counted as correct if the interval selected contained the middle vowel with the higher F2. The correct response was equally likely to be interval one or interval two. Participants made responses by clicking a mouse button while seated at a computer. Visual feedback was presented on the computer monitor after each response indicating whether the response was correct or incorrect. Before completing the test trials, each participant completed 50 practice trials in which they heard a single vowel in each interval of the 2IFC task and were asked to identify in which interval the vowel sounded more like an/i/. Participants were then asked to complete an additional 50 practice trials of the 2IFC task with the vowel triads. In this second practice session the target vowels were 20 dB higher in level than the masker vowels. Finally, the participant completed 16 blocks of 50 trials (800 test trials for each session). Each condition session took about 1 h. Participants were allowed to take breaks as needed between blocks of trials. The participants completed all 800 trials of condition one before moving on to condition two. The order of task completion was randomized across participants.

2.3. Participants

A total of 33 participants completed the study; 16 older adults (10 females and 6 males, ages 56–79 years, mean = 65) and 17 young adults (14 females and 3 males, ages 19–30 years, mean = 22). Pure-tone air conduction thresholds were measured for each participant in both ears at the frequencies 250, 500, 1000, 2000, 4000, and 8000 Hz. Normal hearing for the young adults was considered as thresholds of 20 dB HL or less for frequencies from 250 to 8000 Hz. All younger participants were found to have normal hearing. Normal hearing for the older adults was considered as thresholds of 30 dB HL or less for frequencies 250, 500, 1000, and 2000 Hz in at least one ear (cf. Russo and Pichora-Fuller, 2008; Stewart and Wingfield, 2009). All older participants also had normal hearing by this standard. Table 1 provides average demographic data of the participants. Young adults by self-report verified that they were free from cognitive impairment, dementia, and disease that might alter cognition. The older adults were recruited from the Wisconsin Alzheimer's Disease Research Center (ADRC) participant registry. They were drawn from the normal aging group of participants. As part of their participation as normal controls in the ADRC studies they were verified by physician, neuropsychological testing, and often MRI to have normal cognitive function, and to be free of disease and dementia, and not taking any psychogenic medications.

To evaluate whether the older adults experienced more difficulty understanding speech in noise in everyday listening than the younger adults, all participants completed the Speech Spatial Qualities (SSQ) Questionnaire (Gatehouse and Noble, 2004). The SSQ inquires about listening abilities in specific situations. The SSQ is sub-divided into three listening functions: speech perception, spatial perception, and quality of sound perception. It is scored on a Likert scale with 0 indicating no ability to hear or listen well in that situation and 10 indicating perfect ability to hear or listen in that situation. A 2×3 ANOVA was performed for the two age groups and the three SSQ sections. There was a main effect of SSQ section score ($F = 5.6$ (2,31), $p < 0.01$), main effect of age group ($F = 15.7(1,31)$, $p < 0.0001$), and near significant interaction effect of SSQ section score and age group ($F = 2.6$ (2,31), $p = 0.07$). Pair-wise comparisons were calculated using Tukey HSD. There was a significant difference between young ($M = 8.5$, SD $= 1.0$) and old adults ($M = 7$, SD $= 1.4$) on the speech in noise ratings ($p < 0.01$), but not on the scores for the spatial or quality sections. The older adults gave lower ratings of their ability to understand speech in noise than the younger adults.

In addition to the SSQ questionnaire, each participant completed a test of working memory, the Wechsler Memory Scale Revised digits span test (Wechsler, 1981), and a test of inhibitory control, the D-KEFS Color-Word Interference Test (Delis et al., 2001). During the D-KEFS test, the participant was given a sheet of paper with color words printed in black ink (congruent condition). They were asked to read the words as quickly as possible without skipping any or making mistakes. The time it took them to read the words was recorded. The participant was then given another list of color words, but this time the words were printed in conflicting colors of ink. For example, the word red was printed in blue ink (conflicting condition). The participant was asked to name the color of the ink and not read the word. Again the participant was timed. The measure of inhibitory control was calculated by subtracting the congruent condition time from the conflicting condition time. Larger time differences indicated less inhibition. The means of the time differences were 41 s (SD $= 24$) and 20 s (SD $= 7$) for the older and younger adults, respectively. During the digit span task, the participant heard strings of digits ranging in length from 2 to 7 digits. After each string the participant was asked to repeat the string of digits in the reverse order in which they were heard. For example the string 5-4-3 would be repeated back as 3-4-5. The backward digit span lengths were 7.1 digits (SD $= 2$) and 7.8 digits (SD $= 3$) for the older and younger adults, respectively.

Table 1
Mean and standard deviations (SD) of the demographic variables for older and younger participants. The SD values are in parentheses. PTA = pure tone average.

	Age	PTA	0.25–2 kHz	4–8 kHz
Older adults	65 (8)	22 (12)	15 (10)	35 (20)
Younger adults	22 (3)	2 (5)	3 (6)	1 (5)

3. Calculation of decision weights

The method of Lutfi and Liu (2011), a variation of perturbation analysis as described by Berg (1990), was used to estimate decision weights (for complete development the reader is referred to Lutfi and Liu, 2011). Let ΔT denote the difference in F2 of the target between the first and second intervals of the two-interval, forced-choice trial, and let ΔM denote the corresponding difference in F2 of the maskers. A logistic regression was performed on the trial-by-trial data for which the probability of an interval one response, $P(R = 1)$, was given by.

$$\mathrm{logit}[P(R = 1)] = c_1 \Delta T + c_2 \Delta M + e \tag{1}$$

where c_1 and c_2 are regression coefficients and e is the regression error taken to reflect internal noise resulting from limits in encoding efficiency. The decision weight participants placed on the masker relative to the target was estimated from the obtained regression coefficients according to

$$w = \frac{c2}{c1 + |c2|}. \tag{2}$$

Note here that w can have either a negative or positive value, a negative value indicating a comparison between target and masker, a positive value indicating some form of ‘confusion’ of target and masker or perceptual effect of the masker on the target (cf. Lutfi and Liu, 2011; Summerfield et al., 1984). Perceptual after effects have been shown using vowel compliment spectra and uniform spectra presented in sequence, wherein the initial spectrum influences the perception of the second. The optimal listening strategy, the one yielding best performance, gives a weight of zero to the masker. Any weight other than zero yields performance equal to.

$$\mathrm{PCweight} = 100(1 - w + 0.5w) \tag{3}$$

assuming no internal noise, $e = 0$. Where the weight is close to or equal to zero and performance is still poor, then the poor performance is attributed to internal noise. For the present study, it was expected that performance would reveal a combination of non-optimal weights and internal noise.

4. Results

Fig. 1 gives the average percent correct scores for each condition for each age group. There were no ceiling effects, as the average performance for each condition ranged between 70% and 81%. An ANOVA was performed on the d' scores calculated from the percent correct scores (Macmillan and Creelman, 1991). The main effects of age group ($F = 12.3(1,31)$, $p < 0.001$) and condition ($F = 8.0(1,31)$, $p < 0.01$) were significant. There was no interaction between age group and condition ($F = 0.3(1,31)$, $p > 0.05$). The older adults performed more poorly than the younger adults. For both groups, the F0-different condition yielded the best performance. The improved performance with different genders of the target and masker speakers is consistent with previous data (Brungart, 2001).

Each panel in Fig. 2 shows the relative decision weight on the masker, w (ordinate), and corresponding performance level in d' for the two conditions. Different colored symbols represent the data

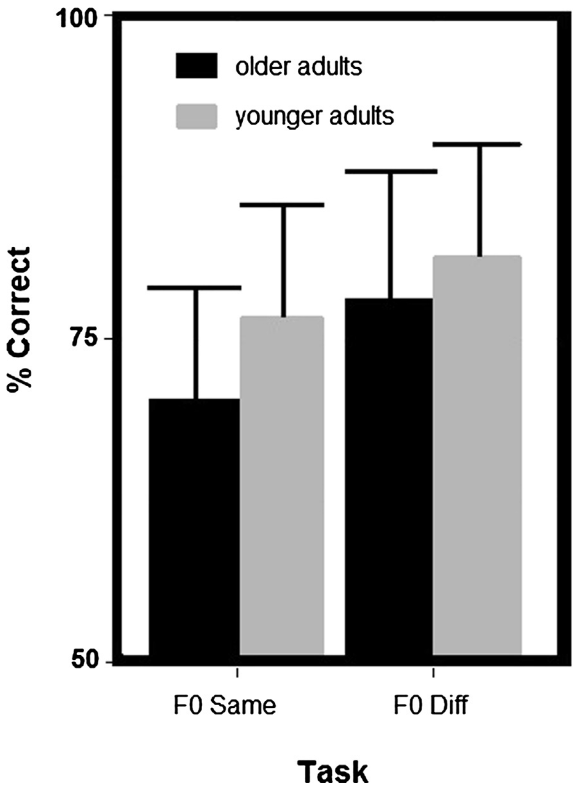

Fig. 1. Average percent correct for each vowel discrimination task. The black and grey bars show average percent correct for the older and younger adults, respectively. Error bars show ± standard error of the mean.

from different participants (average of 800 trials per point). Error bars give 95% confidence intervals. The first and second columns show data for the older and younger adults, respectively. The first row is for the F0-same condition, in which the F0 of masker and target vowels was the same. The second row is for the F0-different condition, in which the masker and target vowels differed in F0. The dashed lines are predictions for performance from Eq. (3), assuming that performance is limited only by the weights, with no internal noise.

It is evident from Fig. 2 that there was a large degree of variability across and within age groups on both conditions in the performance level and the value of the decision weight. There were individuals on both conditions in both age groups who gave a positive decision weight (points above the zero horizontal line), a negative decision weight (points below the zero horizontal line), and effectively zero weight to the masker relative to the target (points on or near the zero horizontal line). The performance ranged from a d' score of 0.2 to 2.1 for the young adults and -0.2 to 1.9 for the older adults. Some older adults outperformed the young adults and vice versa.

It is obvious from Fig. 2 that very different decision weights can yield the same level of performance. For example, in the lower left panel of Fig. 2, the older adult data represented by the pink and purple points are from two participants who attained a similar d' score of 0.8. The weight for one was negative while for the other it was positive. The same relationship occurred for the younger adults; note the purple and red data points in the lower right plot at a d' of 1. Fig. 2 also shows cases of participants who used the same weights but with large difference in performance; compare the yellow and red points in the lower right panel. Lastly, Fig. 2 shows within-subject variability on performance and decision weights. The weights of some participants differed across tasks with little variation in their performance (see the black points in the older adult column). Still other participants varied their weights on each task as well as their performance (see the red and white points in the older adult column of Fig. 2). These differences are consistent with previous data showing large individual differences in decision weights and performance (Lutfi and Liu, 2011).

To evaluate if the listener's weights were consistent over time and with practice, five older adult participants (3 female) were asked to complete two additional repetitions of each condition. Each session was completed on a different day and the length of time between sessions varied from 2 days to 2 weeks. There were 800 trials for each session. Comparing weights from session 1 to session 2, the correlation was $r = 0.98$ ($t = 8.7$, $df = 3$, $p < 0.01$) for the F0-different condition and $r = 0.97$ ($t = 8.4$, $df = 3$, $p < 0.01$) for the F0-same condition. The correlations between the weights on sessions 2 and 3 were $r = 0.93$ ($t = 4.5$, $df = 3$, $p < 0.05$) and $r = 0.91$ ($t = 4.0$, $df = 3$, $p < 0.05$), respectively. All of the correlations were close to 1. Thus, despite the large differences in weights obtained across individuals and within individuals across tasks, it appeared that the participants' decision weights were consistent over time.

Pearson correlations were calculated between the decision weights and the peripheral (pure tone averages, PTA) and central function measures (inhibitory control and working memory). The results are reported in Table 2. There were no significant correlations between either of the cognitive measures or the PTA values and decision weights among the younger participants. Data from the F0-different condition showed a significant correlation between weights and PTA among the older adults ($t = 2.8$, $df = 14$, $r = 0.60$, $p < 0.05$), indicating that the higher the PTA, the more positive the weight was on the masker. Data from the F0-same condition resulted in a significant correlation between inhibitory control and decision weights ($t = 2.9$, $df = 14$, $r = 0.62$, $p < 0.05$) as well as between PTA and weights ($t = 3.3$, $df = 14$, $r = 0.66$, $p < 0.01$). For the F0-different condition, the older adult's weights were related to the PTA. For the F0-same listening condition, the older adult's weights were correlated with both PTA and inhibitory control. Working memory did not show a significant relationship with the decision weights for either group.

Correlations were repeated using the absolute value of the decision weights to evaluate the extent to which cognitive measures were correlated with the 'magnitude' of the influence of the masker. The results are reported in Table 3. As for the previous analysis, there were no significant correlations between either of the cognitive measures or the PTA and the absolute value of the decision weights among the younger participants. For the older adults there was a significant correlation between the working memory measure and the absolute value of decisions weights on the F0-different condition ($t = -2.9$, $df = 14$, $r = -0.62$, $p < 0.05$). Older adults with a shorter working memory span were more likely to be influenced by the masker. For the more difficult F0-same condition there was a significant correlation between inhibitory control and the absolute value of the decision weight among the older adults ($t = 2.8$, $df = 14$, $r = 0.60$, $p < 0.05$). Older adults who had longer inhibition times had a tendency to give greater weight to the maskers in more difficult listening conditions.

5. Discussion

The current study was designed to evaluate the degree to which older adults differ from younger adults in their decision weights on a simple masked vowel discrimination task and to determine how those individual weights relate to measures of peripheral and central function. A model commonly used in the psychoacoustic literature was implemented to estimate the decision weight on the masker (positive or negative). The weights varied across the two

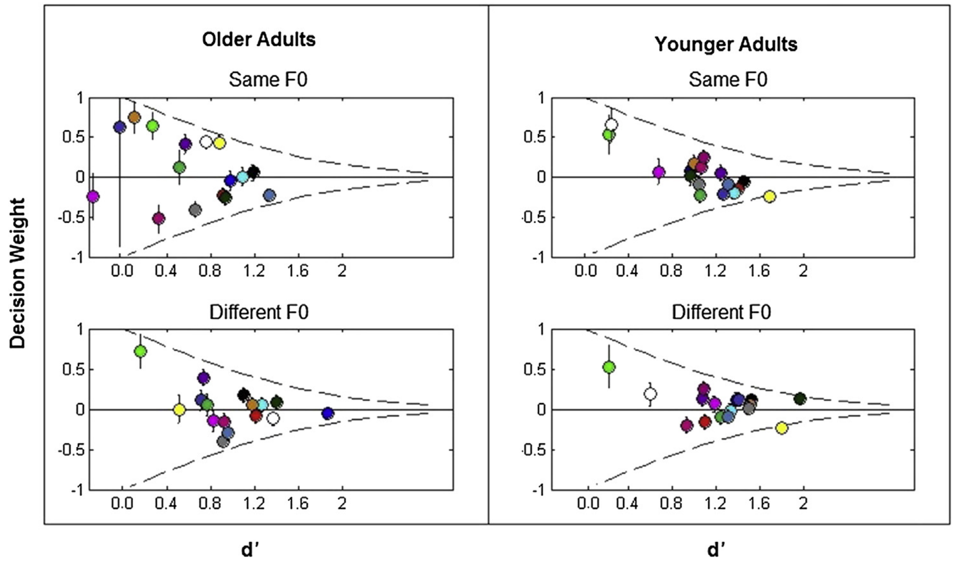

Fig. 2. Each panel gives the relative decision weight on the masker, *w* (ordinate), and corresponding performance level in *d′* for the two conditions. Different colored symbols represent the data from different participants (average of 800 trials per point). Error bars give 95% confidence intervals. The first and second columns show data for older and younger adults, respectively. The first row of plots is for the F0-same condition in which the F0 of masker and target vowels were the same. The second row is for the F0-different condition in which the F0s of the masker and target vowels were different. The dashed lines show predictions of performance from Eq. (3), assuming that performance is limited only by the weights.

conditions, both between and within participants. Moreover, the analysis revealed individual differences in decision weights that were not evident in the performance measures alone. On the more difficult F0-same condition, the older adults with less inhibitory control and higher PTA had more positive decision weights. In addition, the decision weights were more influenced by the masker if the older adult had longer inhibition times. For the less difficult F0-different condition, the older adults' decision weights were more positive if they had a higher PTA, and the decision weights were more influence by the masker if the older adult had a shorter working memory span. The younger adults' decision weights had little relationship to any of the peripheral or central measures in either condition.

The dissimilarity of correlations with the decision weights and the two cognitive measures across conditions may indicate a difference in the type of cognitive functions that are important for difficult vs easy listening conditions that is independent of PTA among older adults. Based on the present study, inhibitory control may play a larger role on decision weights and performance on difficult tasks while working memory may play a larger role on easy tasks. There is also the possibility that another cognitive function not tested in the present study would yield a more significant relationship with decision weights and task difficulty. Research has shown that speed-of-processing greatly influences older adult's performance on speech in noise tasks (Gordon-Salant and Fitzgibbons, 2004; Pichora-Fuller, 2003; Wingfield et al., 1985). In the future, adding a speed of processing measure as well as varying the rate of presentation of the stimuli may prove beneficial in understanding speech-in-speech perception and the factors that influence individual differences in older adult's performance and decision weights.

It is important to underscore, as with any study of this type, that results may have been influenced by sample bias and sample size. The older adults who participated in the study attained neuropsychological test scores in the upper percentiles compared to their age matched norms. In addition, according to the US Census Bureau's Current Population Survey, 2012 Annual Social and Economic supplement, the average years of education attained by the older adults in the study placed them among the 10% of American citizens to have 16 years of education in the age group 55 years and older. Five of the 16 older adults received doctoral degrees, putting them among the top 1.6% of Americans in their age group. The older adults were all extremely active in the research community on the UW-Madison campus as well as in their own neighborhoods. If the sample of older adults had been taken from a more "typical" pool of older adults, greater differences between the young and old adults

Table 2
Pearson correlation values between the decision weights and the Wechsler Memory Scale Revised digits span test (working memory), the D-KEFS Color-Word Interference Test (inhibitory control), and PTA in both ears (Threshold). The left and right panels show data for older and younger adults, respectively.

	F0 same	F0 diff.
Older		
Working memory	0.08	−0.16
Inhibition	0.62*	0.42
Threshold	0.66*	0.60*
Younger		
Working memory	0.13	−0.08
Inhibition	0.33	0.17
Threshold	−0.28	−0.029

Table 3
Pearson correlation values between the absolute value of the decision weights and measures of working memory, inhibitory control, and PTA. The left and right panels show data for older and younger adults, respectively.

	F0 same	F0 diff.
Older		
Working memory	−0.18	−0.62*
Inhibition	0.60*	0.47
Threshold	0.46	0.15
Younger		
Working memory	−0.05	−0.22
Inhibition	0.29	0.06
Threshold	−0.23	−0.024

might have been revealed. The older adults also had a higher PTA for both ears than the younger age group. The degradation in higher frequency hearing might have played a role in task performance (refer to Table 1). To mitigate this issue, synthesized vowels with steady state formants with frequencies at or below 2000 Hz were used. All of the participants had normal hearing at those frequencies.

The vowel discrimination task also limited the generalization of the findings to "real world" speech perception among distracters. From these data it is difficult to determine if there would be differences in decision weight with more complex speech stimuli (consonants, words, sentences). Discriminating one vowel from the next out of context was an unfamiliar listening condition for all of the participants as they had no previous psychoacoustic research experience. The decision weights in this task might have a stronger relationship to how participants segregate in novel listening situations than in familiar listening situations. The decision weights were found to be relatively stable over the course of three repetitions of each condition, but given the small sample and limited variety of listening conditions and stimuli, a more rigorous investigation on the flexibility of decision strategies is needed.

While it may be difficult to generalize the vowel discrimination results and administer the masker-target-masker triad conditions and calculate decision weights in a clinical setting, the present study suggests that such a generalization might not be necessary. The relationship of cognitive functions and individual differences among the older adults decision weights suggest it might be beneficial to administer a brief test of working memory or inhibitory control to assist in understanding how greatly a masker will influence a client's ability to perform in noisy listening settings outside of the controlled laboratory or clinical environment. This additional information along with PTA and speech audiometry may help the clinician provide an individualized therapy plan as well as more realistic expectations for the client's benefit from different treatment options. Measures of cognitive function have already been applied toward selecting specific hearing aid algorithms in an attempt to improve speech perception in noise (Lunner, 2003).

The weighting analysis applied in the present study builds upon the currently available research by capturing individual differences that would otherwise remain unexplained by metrics of performance accuracy, such as d' or PTA. Differences in performance on speech in noise tasks are not fully predictable from PTA (Anderson et al., 2013; Léger et al., 2012). One of our older adult participants, for example, attained a d' score of 0.6 (68%) on the F0-same condition and had a PTA of 0.8 dB HL. On the same task, another older participant with a PTA of 19 dB HL attained a d' score of 1.1 (79%). The difference is related to their weights. The participant with the lower PTA had a highly positive weight on the masker while the participant with the higher PTA gave little weight to the masker. The weighting analysis helps capture differences that are not accounted for by the audiogram or even percent correct scores. The present study provides a means to delve even deeper into the individual differences of older adults′ perception of speech-in-speech.

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